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Methodological and Ideological Options

A quantitative representation of the urban green building model, focusing on local climatic factors by utilizing monetary valuation

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ABSTRACT

The environmental attitude associated with sustainable development includes the belief that the manipulation of ecosystems has a negative effect on natural evolution. Therefore, monitoring and controlling mechanisms have been developed for urban construction activities. Accordingly, urban green building ranking systems have been established around the world. However, Iran does not have its own system, nor does it follow any existing system due to political relationship issues. Through conducting literature reviews, this study introduces a new method of regulating green buildings based on the temperature factor of local climates and the sequestration of carbon on green covers, besides integrating the results of monetary studies with judgments of experts in AHP technology to effectively reduce energy consumption and its consequences carbon dioxide (CO_2) emissions. Taking into consideration the varying climatic conditions of the country, a separate quantitative model of assessing and ranking buildings has been developed for each of 600 cities considered; in such a way that it minimizes climatic disadvantages. Finally, the criteria for a green building assessment were used for a single district in Tehran containing 1195 residential building; the assessment found that the studied buildings utilized only 26% of the building capabilities considered as "green".

1. Introduction

The proportion of the urban population relative to the rural population is rapidly increasing. In 1950, 30% of the world's population lived in cities, and it is expected that until 2050, this proportion will grew up to 66% (United Nations, 2015). Cities have undergone significant environmental degradation, and in developing countries, the rate is rising alarmingly (El Araby, 2002). DeFries et al. (2010) show that due to the growth of the urban population, tropical deforestation occurred because of product manufactured for export to other cities.

Urban buildings consume a large share of resources, including energy, water, and electricity (Dixon et al., 2008). Thirty percent of total greenhouse gas emissions and 40% of total energy consumption are attributable to buildings (United Nations, 2009). These facts indicate the need for a control system for urban buildings to minimize their resource needs and waste disposal networks in order to reduce the considerable volume of CO_2 emissions from them (Hamid et al., 2014). The Environmental Protection Agency (2016) provides a definition of green building: "*Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient … Green building is also known as a sustainable or high performance building*" (EPA, 2016). Although the equipment of green building criteria can be costly, it also increases the value of the property (Fuerst and McAllister, 2011). In this regard, _as shown in Fig. 1_ for > 20 years, many countries in the world have developed various green building ranking systems, and many other countries that do not have such systems follow one of the existing ones (Suzer, 2015; Vierra, 2016; WELL Building Standard, 2016; Sharifi and Murayama, 2013).

The International Facility Management Association (IFMA, 2015) has introduced several green building ranking systems and makes a comparison between them. Some examples of well-known green building ranking systems may start from BREEAM in 1990 and continue with LEED in 2000, CASBEE in 2001, Green Star Australia in 2002, Pearl of the United Arab Emirates (Dubai Urban Planning Council, 2010, 2011) and the Jordan Saba (Ali and Al Nsairat, 2009), until Green RE Malaysia in 2012. In 1999, the Green Building World Association was created with 8 members (Lockwood, 2006; World Green Building Council, 2015; Zuo and Zhao, 2014), and currently, there are approximately 100 active members in this community from 80 countries.

The evaluation criteria for the four BREEAM, LEED, BEAM Plus and

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Fig. 1. Countries using green building ratings systems.

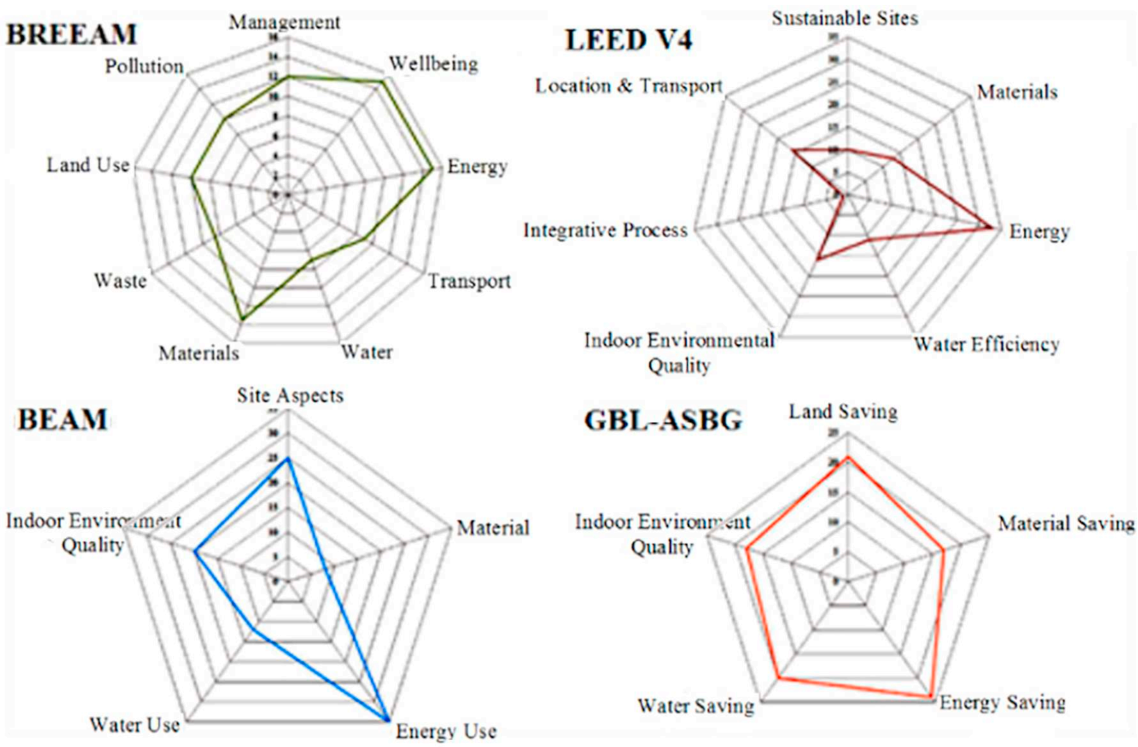

Fig. 2. Comparison of indicator weights in the four most famous green building rating systems (Chen et al., 2015).

ASBG systems (in Fig. 2) show that the highest weight is attributed to the energy benchmark (Chen et al., 2015). This difference in weights between energy and other indicators is also much greater in the LEED and BEAM Plus systems. These comparisons show that, progressively, the theme of the ecological building leans towards active or passive buildings with zero energy (Voss et al., 2011).

Studies have also examined whether Energy Star-certified buildings, for example, have been successful in saving energy (Li and Carrión-Flores, 2017).

Although weights are very important in modelling, no precise numerical determination of coefficients can be made for green building models because quantitative estimations and accurate monetary evaluations have not yet covered all ecosystem benefits (Hong Kong BEAM Assessment Tools, 2004). To formulate a green building ranking system, one must first identify the main criteria and then weights each of the criteria (Sant and Borg, 2016). In this study, a method has been suggested that, facilitates' the utilization of any number of completed monetary studies outcome. Hence availing the selection of the components of green buildings and, specifying their related weights. Further development of related monetary studies would effectively

contribute towards and enhance the qualities of green building systems.

The second disadvantage of the current green building systems is that, their ratings are established without any correlation to the local climatic conditions of the building. Such a rating, regardless of the location of the building, assigns' a fixed quality grade to the building.

This article suggests that, based on the results of relevant monetary valuation studies, the temperature factor of local climate is taken into account in the development of green building assessment model, which generates a distinctively effective model for every city in the country. This study is trying to show that it is different from other similar models in considering local climatic parameters for defining the indexes, and using the results of monetary studies for weighing them.

The paper is organized into four additional sections. In the second section a brief description of the related researches in Iran, the stages of the research, the localizations due to the monetary evaluations and, lastly, the model indicators are introduced. In the third section, the generalization of monetary valuations is presented in model weights, and then the computer tools implemented for the research are described. In Section 4, a case study and its results are presented and the models of two different cities (in terms of climate temperature) are evaluated and discussed. Finally, we apply the conclusion in Section 5.

2. Methods and materials

2.1. Green building in Iran

Iran has a good background of appropriate architecture to passively address the hot climate. With the discovery of oil and gas in Iran, these types of architecture have given way to a new architecture in which the suitable temperature has been provided with heaters and coolers. In this respect, the Ministry of Housing and Urban Development of the country has developed 20 different topics in the field of building regulations in 2009, of which the 19th one addresses the energy saving issues (National Building Regulations Office, 2009). However, due to sanction and some political issues, Iran is not officially associated with any ranking system for green buildings.

Amirkabir University is developing a ranking system for Iranian green buildings based on the LEED system structure with local customizations (Maknoon, 2018). The National Physical Plan project offers architectural solutions for a variety of country climates (Tofigh, 2008). It is expected that over the next 100 years, the limits of climate extremes will even increase (Hitaj et al., 2018). In such a situation, it is necessary to establish green building regulations in Iran according to each local climate, which will both provide an environmental balance and reduce energy consumption.

In this research, a quantitative assessment model of green buildings has been developed for 600 cities. This model has been influenced by the local climatic conditions of each city to minimize the climatic disadvantages and to offer more comfort for the residents. The results of monetary valuation studies of ecosystem benefits were localized and used, as well, to improve the accuracy of the weights of model parameters.

2.2. Analysis and processing

As shown in Fig. 3, this research was conducted in four branches:

1. Reducing energy consumption for heating and cooling.
2. Reducing the peak temperature and urban heat islands.
3. Increasing carbon sequestration volume through green cover.
4. Increasing the use of renewable energy and efficient appliances.

This model was developed on the basis of integrating the ecological and constructional dimensions of urban developments. By identifying the factors involved in the calculations of related monetary valuations and using expert judgements for different categories that have been obtained from land zonings, the model indicators were determined and weighed primarily. After designing the hierarchy tree structure of the model and performing Analytic Hierarchy Process (AHP) (Weiss and Rao, 1987), using a collection of produced computer programmes, an appropriative green building model was developed for each of the 600 cities in the country that were adapted to their local climate. The green building model of metropolitan Tehran was implemented for one of its districts and the results were analysed.

2.2.1. Monetary evaluation for heating and cooling

In West (2010), there are 8 climatic tools for monetary valuation calculations, of which only the tools for "reducing energy consumption for cooling" is completed, the rest is half finished or only their quantitative or qualitative studies have been completed. In this study, the localization of "reduction of energy consumption for cooling and heating", "reduction of heat peak in summer and effects of urban heat islands" and "carbon sequestration in woodland" been realized. Their functions have been extracted from recursive related cells of excel datasheets.

Calculation functions of the monetary evaluation upon heating and cooling showed that green roofs reduce the internal temperature during warm seasons and reduce the required energy for cooling (function (1)), and how much does it worth. Also shows that its amount depends on the amount of which factors.

Knowing these parameters and their relation functions, it is possible to localize the subject, and determine its weight compare to other evaluated subjects such as "energy savings for cooling". The presence of at least 3 trees in the outdoors at a distance of < 10 m from buildings (or construction green walls) increases the internal temperature during cold seasons and reduces energy requirements for heating (function (2)).

In the formulas below, the green lines are the titles and their units. The red lines are sub functions that may use other sub functions or variables recursively. The black lines are brief descriptions and units of results. All functions and variables are named as their related spreadsheet cell names.

C17 : (£/kgCO_2/yr) Tool 1.2 output-1.2 Avoided carbon emissions from building energy savings for heating ;
C17 =C15'Values library'!D18/1000*
C15 : (kgCO_2) CO_2 saving ; =C6'Values library'!D9*
C6 : (kWh (gas)) Energy saving for residential properties ; =C5'Values library'!D7*'Values library'!D14*
C5 : ( ) Residential buildings with large trees < 10m ;
C5= User Defined
'Values library'!D7 : (kWh) Average UK household energy consumption (gas) - (Mid/average);= 16000
'Values library'!D14 : (%) Average energy savings (heating) domestic - (Mid/average) ; = 0.03
'Values library'!D9 : (kg/kWh) CO_2 emission factor of natural gas - (Mid/average) ; = 0.203
'Values library'!D18 : (£/tonne) Social value of carbon - (Mid/average) ; = 6 (1)

C50 : (£/kgCO_2/yr) Tool 1.6 output- 1.6 Avoided carbon emissions from building energy savings for cooling ;
C50 =C48*'Values library'!D18/1000
C48 : (kgCO_2) CO_2 saving ; =C41*'Values library'!D8=C41*'Values library'!D8
C41 : (KWh/yr) Annual energy consumption reduction ; =C37*(1/'Values library'!D16)*'Values library'!D17*C38*C39/1000
C37 : (m2) Net additional area of green roof ; =('Project Data '!E12-'Project Data '!D12)
'Project Data '!E12 : (sq.m) Total area of green roofs – After ; = User Defined
'Project Data '!D12 : (sq.m) Total area of green roofs – Before ;= User Defined
'Values library'!D16 : (%) Average efficiency – (Mid/average) ; = 33%
'Values library'!D17 : (w/m2) Green roof, heat dissipation – (Mid/average) ; = 150
C38 : (%) % building(s) air conditioned ; = User Defined
C39 : (Hrs/yr) Yearly air conditioning use ;= User Defined
'Values library'!D8 : (kg/kWh) CO_2 emission factor of grid electricity – (Mid/average) ; = 0.537
'Values library'!D18 : (£/tonne) Social value of carbon - (Mid/average) ; = 6 (2)

The natural gas network spans across all city points in Iran and may assume that all the urban areas use gas for heating during the cold seasons (Statistical Center of Iran, 2014; Ali Noroozi, 2009). The Iran National Gas Company has identified 600 urban areas in terms of natural gas consumption and divided them into 4 categories. Implementing spatial analyses, such as the Triangular Irregular Network (TIN), contour curves, and topology tools; a quaternary zoning map depicting the natural gas demand for heating homes was constructed based on 2013 data (Fig. 4-a), and the results are shown in the 2nd and 3rd columns of Table 1.

Generally, electricity is used to cool homes in Iran. As per function (2), CO_2 emissions due to electric power consumption in the UK amounted to 537 g/kW·h. According to the amount of fuel consumed in Iran by the power plants in 2013, which produced 203,088 million kWh of electricity, the amount of this coefficient obtained was 709 g/kW·h and was taken into the calculations of localization. Topic 19 of the National Energy Conservation Regulations (National Building Regulations Office, 2009) classifies all cities into 4 categories according to their energy needs for cooling buildings. Similar to the gas zoning map, a quaternary zoning map of electricity demand for cooling houses was devised as in Fig. 4-b, and the results are shown in the 4th and 5th columns of Table 1.

By combining the two sources of CO_2 emissions, the 16 regions of the country were identified, as shown in the 6th and 7th columns of Table 1 and Fig. 4-c. The results indicate that in 2013, 54,243 million kilograms of CO_2 were released into the atmosphere to heat-up and

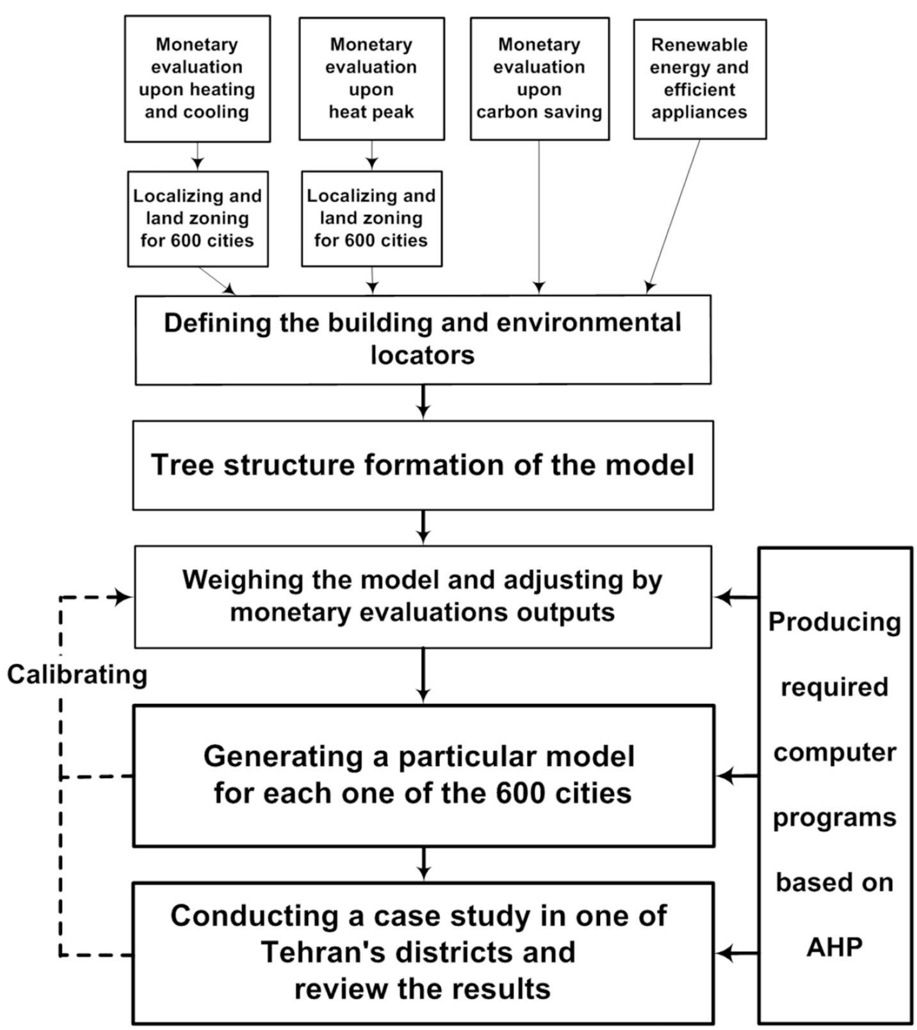

Fig. 3. The steps of this research.

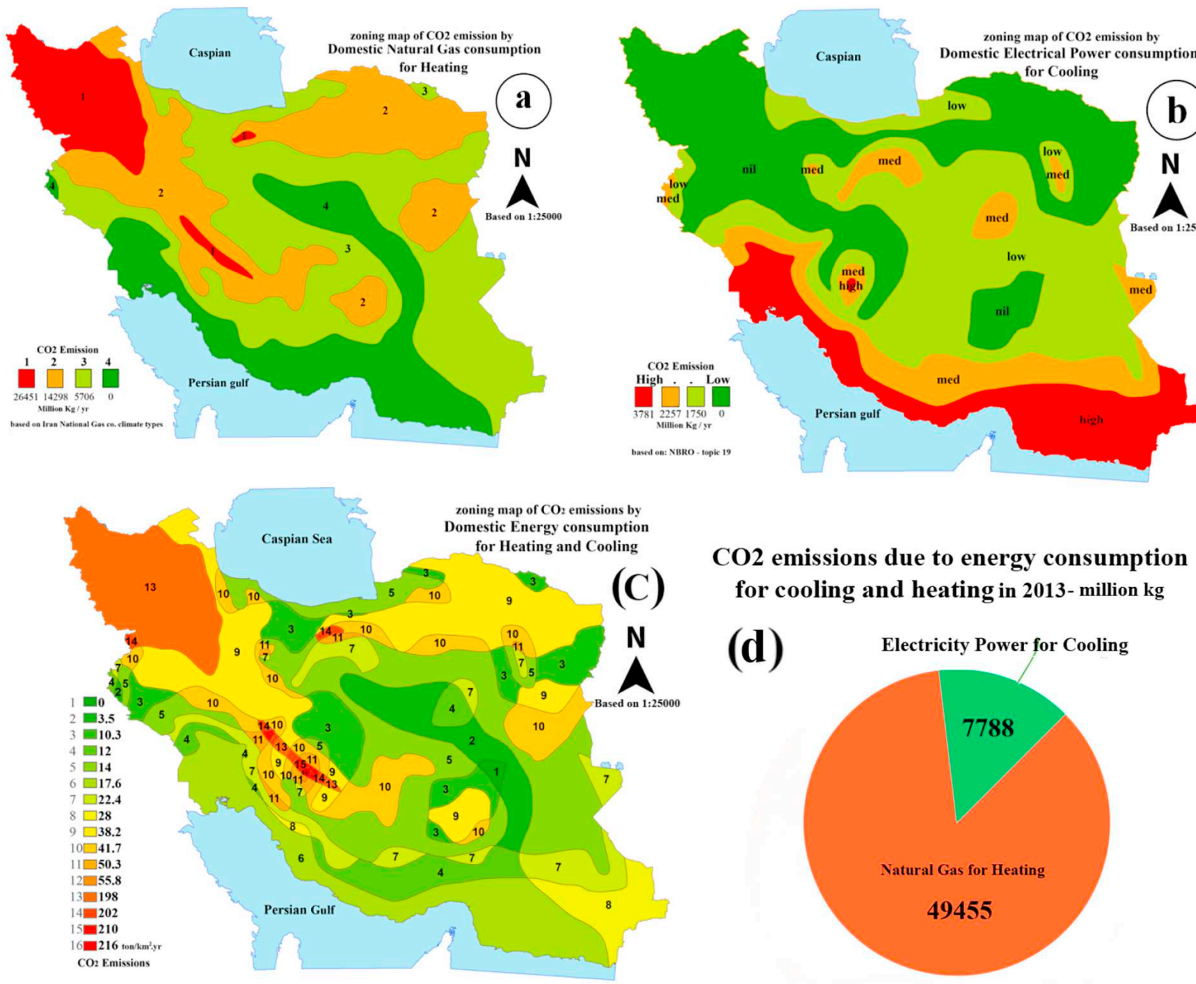

Fig. 4. Maps produced in this research to classify the energy demands for cooling and heating the homes of the country. a) Classifications of CO_2 emissions released due to the domestic consumption of natural gas for heating purposes. b) Classifications of CO_2 emissions released due to the domestic consumption of electricity for cooling purposes. c) Classifications of CO_2 emissions released due to the energy used for heating up and cooling down homes. d) Comparative chart of CO_2 emissions from using electricity power for cooling homes and natural gas for heating them.

cool-down houses in the country. Fig. 4-d shows that the amount of carbon dioxide emissions from using natural gas to heat is approximately six times higher than the emissions from cooling homes by electricity.

2.2.2. Green space monetary evaluation for peak heat reduction and CO_2 absorption

The absence of green space in an area may increase the urban heat island temperatures above 40 °C, whereas increasing green spaces can

Table 1
Sixteen classifications of households energy demands for cooling and heating.

EC # class	Heating class	CO_2 emissions kg/km^2/yr	Cooling class	CO_2 emissions kg/km^2/yr	Total CO_2 emissions ton/yr	Total CO_2 emissions kg/km^2/yr
1	4	0	0	0	0	0
2	4	0	1	3502	244,083	3502
3	3	10,305	0	0	1,117,509	10,305
4	4	0	2	12,115	863,497	12,115
5	3	10,305	1	3502	4,032,663	13,807
6	4	0	3	17,598	2,827,050	17,598
7	3	10,305	2	12,115	2,255,410	22,420
8	3	10,305	3	17,598	1,487,868	27,903
9	2	38,262	0	0	8,752,044	38,262
10	2	38,262	1	3502	5,505,454	41,764
11	2	38,262	2	12,115	573,615	50,377
12	2	38,262	3	17,598	18,249	55,860
13	1	198,609	0	0	24,567,788	198,609
14	1	198,609	1	3502	1,236,248	202,111
15	1	198,609	2	12,115	645,770	210,724
16	1	198,609	3	17,598	118,426	216,207

EC: energy consumption.

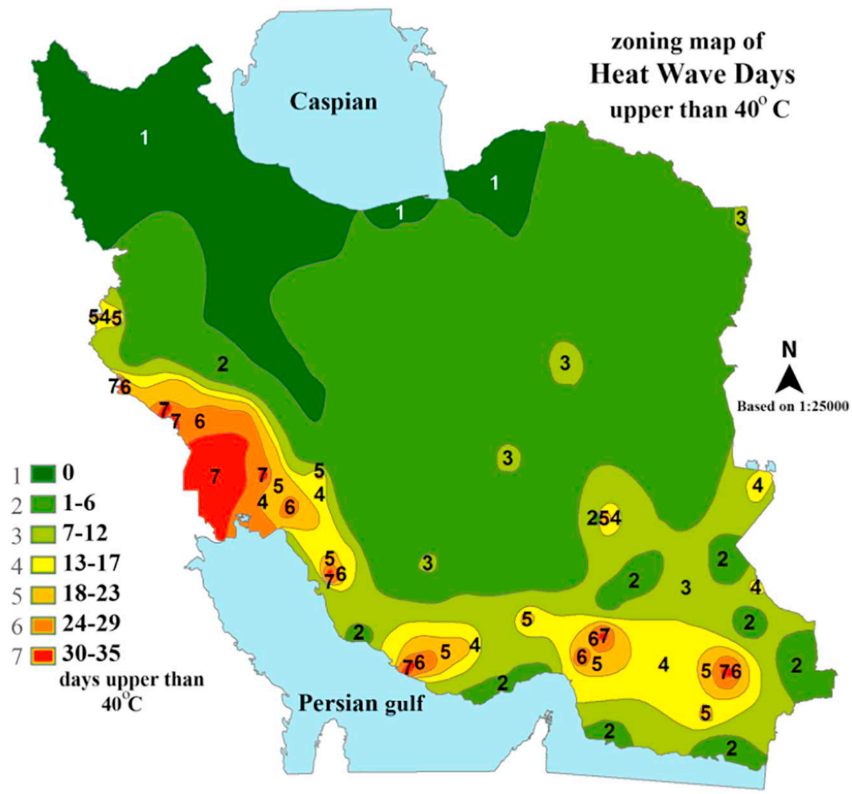

Fig. 5. Zoning of heat waves based on the number of consecutive days above 40 °C (Kiyaie, 2012).

Table 2
Environmental locators and construction components.

Urban construction components C_UCC	Indoor effects C_ine		Green roof	C_grf
			3 trees or green wall	C_3ts
	Outdoor effects C_oue		Impervious surfaces	C_iss
			Trees	C_trs
			Shrubs	C_shs
			Mown grass	C_mgs
			Rough grass	C_rgs
			Cultivated surfaces	C_css
			Water	C_wtr
			Bare soil surfaces	C_bss
	Power installations C_wpi		Renewable energy	C_rne
			Green electrical devices	C_ged
Environmental effects locators E_EEL	Air E_air	CO_2 emissions E_cen	Power for cooling	E_pfc
			Power network consumption	E_pnc
			Gas for heating	E_gfh
		urban heat island		E_uhi

reduce it to 30 °C (McPherson et al., 1997). The relationships in monetary function A.1 are used to calculate the rate of heat loss due to the current temperature and the percentage increase in green space (West, 2010). The country's thermal wave zoning map with 7 classifications has been used (Kiyaie, 2012). As shown in Fig. 5, the categories are based on the number of consecutive days that the temperature is above 40 °C.

The Green Infrastructure Valuation Toolkit (West, 2010) was employed to calculate the amount of carbon absorption by woodlands. Monetary function A.2 was used to calculate the monetary value of carbon absorption in forests and woodlands. In these functions, it is assumed that the current plant cover is “grassed” foliage, and that it will be developed by planting broad-leaf trees.

2.3. *Locators of urban green building*

Two groups of indices were defined. A group of indices was in relation to environmental locators, and the other group was in relation to the construction components. The above study led this research to identify and select 12 building components in 3 categories and 4 environmental locators in 2 categories. In Table 2, the list of these components is presented with their abbreviated words.

The environmental locators that would be affected by their related construction components were then defined as a hierarchy tree structure. The result of this process is illustrated as environmental and construction trees, similar to Fig. 7, which identifies the type of effects of construction components on environmental locators (the numerical values in Fig. 7 are explained in Section 3.2.1).

3. Implementation

The implementation process consisted of two main parts, as illustrated in Fig. 6. Firstly there was a section for generating and developing models, and in the second part there was a section for assessing and ranking buildings. In the first section, it was possible to define the tree structures for “building components” and “environmental locators” and to establish their relationships. Depending on the location of the desired city and the climatic zones defined by this research, using the pairwise comparisons, Saaty matrices (Barzilai, 1997), and the AHP method, the trees were weighed, and hence, the model of each climatic zone were established. In the second part, the city would be selected and according to its climatic conditions, an appropriate model was obtained. Then, the ecological specifications of the green building are evaluated and the green score of the building was obtained.

3.1. *Units and rankings*

To rank buildings in a desirable manner, two specific units have

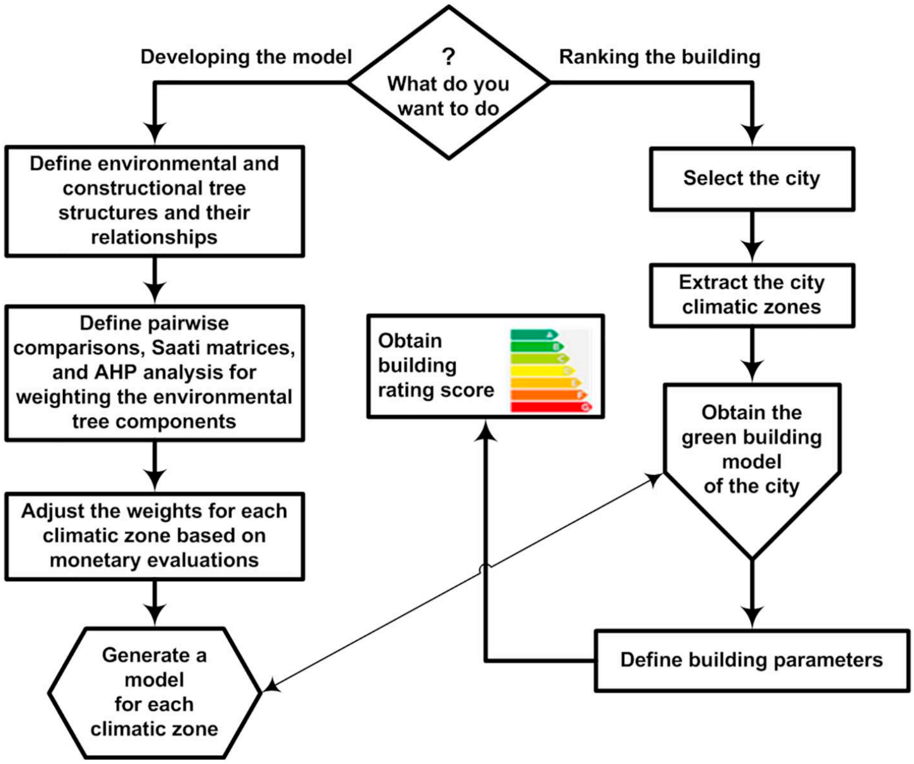

Fig. 6. Block diagram of implementation parts.

been defined. The first unit is for baseline accommodation, which was named Residential Benchmark (RB) and is defined as an accommodation with 100 m^2 of built area and 30 m^2 of open garden. Hence, in every evaluation process, the built-up area and its related open garden are estimated as an equivalent of the "RB" unit.

The second defined unit is the Urban Green Building Unit (UGBU). This unit is comprised of ecosystem advantages of a baseline accommodation (one RB) that completely withholds all of its local green building criteria and is located in a city that requires the least amount of energy needs. Such a hypothetical city should be located in a region where the air temperature is so balanced, and it does not require the use of energy to provide the desirable temperatures during the summer or winter seasons. The reason for defining "UGBU" as a new unit and utilizing it as against using monetary unit is due to the fact that only two numbers out of six indexes of the model, are established through the result of real monetary evaluation studies. The other values have only been derived through formulated calculations based on the weight indexes of the model. Thus they can differ substantially from their real monetary valuations. Using these measurement units, it is possible to estimate how green the property can be based on the green building model of the region and how green it is at the present. The ratio of these two numerical values is the criterion for ranking the property. In this ranking system, the grades increase from "G" to "A"; i.e., scores of < 14% equates to "G" and scores of 28%, 43%, 57%, 71%, 85% and over 85% are ranked up to "A".

3.2. Weighing the components of the model

Since each component in this model has been classified in accordance to its local climatic conditions, the pairwise comparisons of the components for such diversity were difficult. Therefore, as an example, to compare the "urban heat island" component with respect to "CO_2 emissions", seven heat classes were recorded in Table 3 with 16 classes of CO_2 emissions. Then, the four corner points and some of the middle points were determined on the basis of the aforementioned considerations (defined in red). Using a TIN (Triangular Irregular Networks) spatial analysis model, a 3D interpolation was applied to the tabulation and the values of the other cells were derived. Similarly, all other related components were compared pairwise.

3.2.1. Utilizing monetary evaluations

Localized monetary valuation for some of the model components were used for weight adjustments. As an example, Fig. 7 shows this process with numerical values related to the model of Asadabad city,

Table 3
Definition of peak heat comparison weights in relation to CO_2 emissions, using TIN analysis.

Peak heat	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7	5	4.85	4.71	4.56	4.45	4.32	4.19	4.05	3.92	3.87	3.63	3.49	3.36	3.25	3.12	3
6	4.34	4.09	3.87	3.69	3.59	3.45	3.29	3.16	3.05	2.89	2.79	2.65	2.49	2.38	2.32	2.36
5	3.66	3.43	3.19	2.97	2.72	2.54	2.40	2.26	2.16	2.00	1.89	1.74	1.60	1.64	1.64	1.66
4	3	2.75	2.50	2.28	2.06	1.82	1.55	1.35	1.24	1.091	0.97	0.90	0.94	0.96	0.98	1
3	2.32	2.13	1.87	1.62	1.38	1.15	0.95	0.68	0.43	0.2	0.23	0.23	0.26	0.26	0.29	0.3
2	1.66	1.43	1.20	0.96	0.74	0.57	0.51	0.46	0.40	0.36	0.30	0.25	0.20	0.21	0.23	0.25
1	1	0.93	0.88	0.83	0.78	0.73	0.67	0.62	0.56	0.518	0.46	0.40	0.35	0.30	0.24	0.2
	CO_2 emissions															

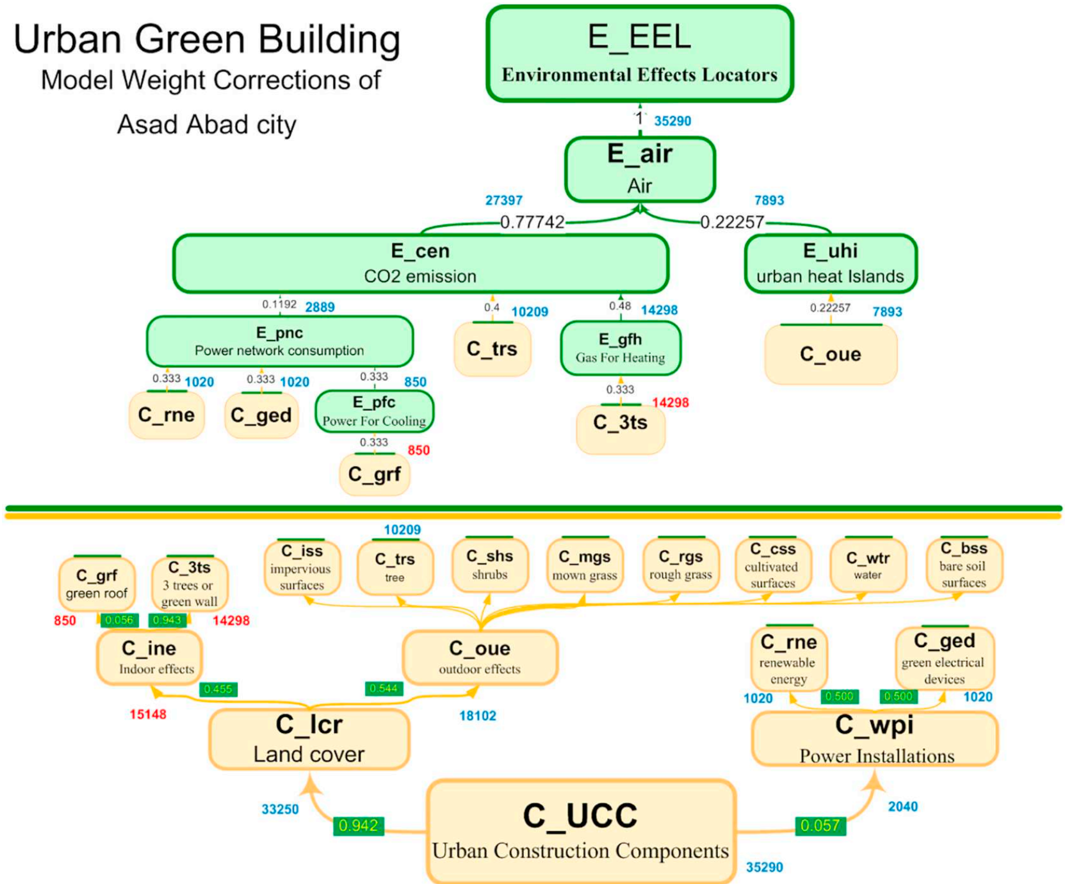

Fig. 7. Utilizing monetary values for the city of Asadabad, Hamadan. (For interpretation of the references to colour in this figure, the reader is referred to the web version of this article.)

which is located in a cold region of Hamadan province. The primary coefficients of the environmental components are specified by black numbers. The values of monetary valuation for the components of "at least 3 trees in the yard" and "green roof" are inserted by red numbers in the ecological tree schema. These values are measured in the UGBU units and for 1 RB house. Computing the average of these red values with the proportion of previously black coefficients, the numerical values were then obtained for each link in the ecological tree schema (the blue numbers). Using the values of the environmental components, the corresponding construction components were defined (blue numbers in the construction tree). Depending on the ratio of these values, the coefficients of the building components were then computed (yellow numbers on green background), hence concluding the green building model of the city. Function (3) shows how the coefficients of the sub-nodes are multiplied by each other to obtain the model coefficients, and function (4) shows the result of the model for the city of Asadabad.

$$C\_UCC = 0.942 * 0.455 * 0.056 * C\_grf + 0.942 * 0.455 * 0.943 * C\_3ts + 0.942 * 0.544 * C\_oue + 0.057 * 0.500 * C\_rne + 0.057 * 0.500 * C\_ged \quad (3)$$

$$C\_UCC = 0.512 * C\_oue + 0.404 * C\_3ts + 0.028 * C\_rne + 0.028 * C\_ged + 0.024 * C\_grf \quad (4)$$

With regard to the coldness of the area, the presence of trees that help heat the house and absorb carbon has a much higher priority than the green roof. It is also possible to generate the model via the monetary calculations amounts of building components, or producing a relative model such as function (5), in which the coefficient of C_UCC is the amount of green building services obtained for each 1 Rd unit house in that city.

$$35290 * C\_UCC = 18102 * C\_oue + 14298 * C\_3ts + 1020 * C\_rne + 1020 * C\_ged + 850 * C\_grf \quad (5)$$

Since each 31,792 units in this study, equals one UGBU unit, then function (5) can be written as function (6) based on UGBU unit.

$$1.11 * C\_UCC = 0.57 * C\_oue + 0.45 * C\_3ts + 0.032 * C\_rne + 0.032 * C\_ged + 0.027 * C\_grf \quad (6)$$

3.3. Computer programming

It was essential to repeatedly remodify the structure and components of the model to formulate the model, and it was necessary that appropriate reports be available from the results to test the model's performance and to make possible revisions and calibrations. For this purpose, a group of specific software tools were written by A. Madad – Tehran/Iran. The main sections are presented along with interfaces in Fig. 8. The programmes help both developing models and ranking buildings.

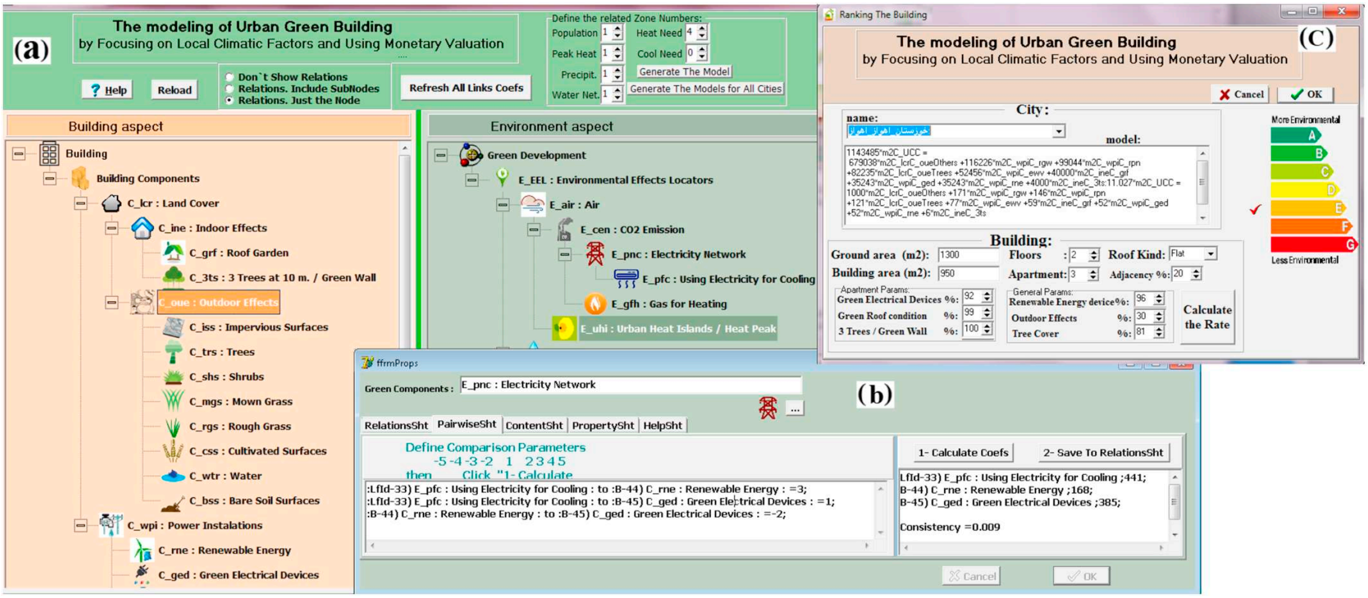

Fig. 8. Interfaces of implemented tools. a) Tree structures for building components and environment locators. b) Weighing the model using pairwise comparisons and AHP method. c) Generating the model of each city and ranking the buildings.

4. Results and discussions

To conduct a case study, a district of Tehran Region 1 was selected. That district had a total of 1195 residential parcels that use the natural gas network for heating and the electrical network for cooling. The study was conducted on the basis of the “Property Assessment” database from Tehran Municipality in 2006. With initial analysis of the study area and in comparison with the model trees structure, the following fields were added to the tables of the database:

Table 4
The result of the ecological building evaluation of the case study area.

Age	Amount	Green-capability[a]	Green-existent[a]	Green-lack[a]	Green-rate %
Old	296	310	204	106	65 (C)
Medium	719	2699	868	1831	32 (E)
New	180	2991	488	2503	16 (F)
All	1195	6000	1560	4440	26 (F)

[a] Values are based on UGBU.

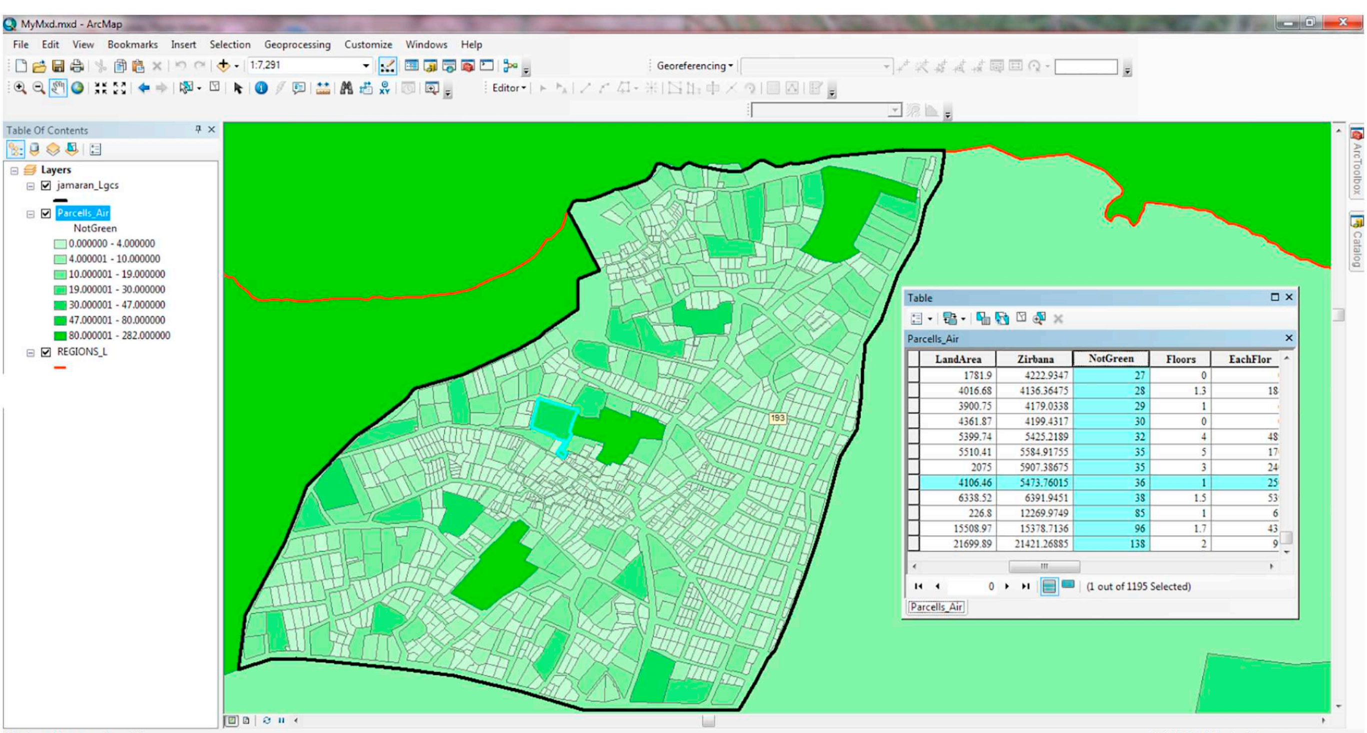

Fig. 9. Results of the green building assessment of a Tehran district. (For interpretation of the references to colour in this figure, the reader is referred to the web version of this article.)

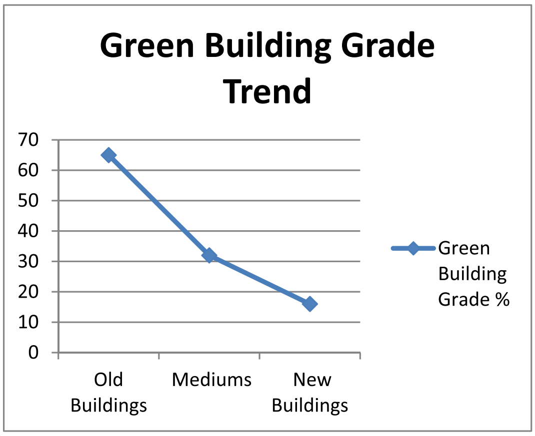

Fig. 10. Downtrend of green building grade in study area.

Age: integer	*building age: 0 old, 1 medium, 2 new*
RoofKind: integer	*0 flat, 1 gable*
Ged: float	*percentage of green electrical devices*
Tts: float	*percentage of 3 trees in the yard/green wall*
RoofGreen: integer	*percentage of green roof*
Rne: float	*percentage of renewable energy*
Oue: float	*percentage of green land cover*
OueTree: float	*percentage of trees in terms of carbon sequestration*
Adjacency: float	*Adjacency to other buildings*
GreenAbl: float	*The green capability of the building*
GreenEx: float	*The green existent of the building*
NotGreen: float	*The green lack of the building*

The land-uses other than "commercial", "non-residential", and "wooded" were considered as "residential". To be able to set the percentage of "green electrical devices" (C_ged) without having to visit the owners in person, the values were initialized upon the age of the house. Fig. 9 shows the result of this assessment in 7 classes, from zero to 282 units of UGBU, upon their lack of green building features and is coloured from light green to dark green, respectively.

The green building model of the Tehran megacity is given in function (7). As explained, it is assumed that the evaluation is performed for 1 RB house in the city, and the result will be in UGBU units. It shows that if a 1 RB unit house in this city is fully equipped with woodland, green roofs, green walls, high efficiency appliances, and renewable energy sources, it would create an environmental worth of 1.18 UGBU.

$$1.18 * C\_UCC = 0.50 * C\_oue + 0.28 * C\_grf + 0.27 * C\_3ts + 0.06 * C\_ged + 0.06 * C\_rne \quad (7)$$

In the Tehran model, the highest weights are given to the components of the "Outdoor Effects" (*C_oue*), and the "green roof" (C_grf). For each assessment, the size of the building was calculated on the basis of the RB unit, and by multiplying it by 0.359 UGBU, its green capability had been obtained; then, upon the percentage of each of the green features that were present there, the green extent of the building was calculated, and consequently, its grade had been achieved. Table 4 indicates the results of the assessment criterions classified by age of the buildings.

As it shows, the overall green building capacity of the district was approximately 6000 UGBU, in which the existence of green building was approximately 1560 UGBU. This outcome means that the green building ranking of the study area was 26%, which was labelled "F". Fig. 10 presents the falling trend of green building grades in the study area. It should be mentioned that these results are due to the evaluation of a model whose indicators only concern the "air" component. Of course, more the "water" component of the model (which is another important environmental component of the country), lead to comprehensive results and, on this basis, more details will be provided in the analysis.

The most important factor in the green building model of Tehran is the factor of outdoor effects (*C_oue*), which includes the presence of trees and green cover in enclosures, floors and roofs. Through the fieldwork, it has been realized that old houses usually have simple and small buildings and have a large yard with trees, but new towers often have large multi-story buildings and usually a very small yard without any trees in it. Additionally, there is no tree or green cover in their vast roofs and outer walls.

At this point, the models of two cities with temperature contrasts are examined and compared. Tabriz is one of the main cities of the country in the cold region and Ahwaz is one of the most important cities of the hot region. The models of these two cities are represented in functions (8) and (9) respectively:

Tabriz

$$81831 * m2C\_UCC = 40000 * m2C\_ineC\_3ts + 28143 * m2C\_lcrC\_oue + 9000 * m2C\_ineC\_grf + 2344 * m2C\_wpiC\_ged + 2344 * m2C\_wpiC\_rne \quad (8)$$

Ahvaz

$$196721 * m2C\_UCC = 82235 * m2C\_lcrC\_oue + 40000 * m2C\_ineC\_grf + 35243 * m2C\_wpiC\_ged + 35243 * m2C\_wpiC\_rne + 4000 * m2C\_ineC\_3ts \quad (9)$$

In the Ahvaz model, in order to reduce the heat peak and the effect of urban heat islands, the "Tree Planting" index is given first priority, and then at the second priority, the "Green Roof" exists, which reduces the energy consumption to warm the house. In the Ahwaz model, in order to reduce the heat peak and the effect of urban heat islands, the "Tree Planting" index is given first priority, and then at the second priority, the "Green Roof" exists, which reduces the energy consumption for cooling the house. "Use of Efficient Electrical Appliances" and "Renewable Energies", as indicators, appears in the next priority with equal weighting. Finally, with a weight close to zero, the green wall index reduces the energy consumption for heating.

In the cold region model of Tabriz, the most important indicator is the existence of "Green Wall" that reduces energy consumption to heat the house. Subsequently, the "Tree Plantation" and "Green Roof" indices are located in the model, resulting in carbon sequestration and energy reductions for cooling the house. At the end of the model, the two equal and very low weight indices, "Use of Efficient Electrical Appliances" and "Renewable Energies", are placed.

As it has been demonstrated, the prioritization and weighting of models are a logical function of the climatic conditions of the region and result in reducing the climate disadvantages to provide a comfortable habitation.

5. Conclusion

Due to the current imposed sanctions and political constraints, that has resulted in reduced the on-going global relationships, new scientific research fields are indeed being delayed and are compounded by substantial knowledge gaps in the country, and on some instances these delays are leading to irreparable losses. One of these research fields is the subject of Green Building. Iran is not currently a member of the World Green Building Council and does not utilize any system of global green building. The outcomes of the presented case study in one of the prominent districts in the capital suggest an accelerated downtrend in the ranking of green buildings grades from 64% to 16%. While the vision of Tehran's comprehensive plan hopes that the development of Tehran's metropolis flourishes as a green city on the completion of the project, however it is necessary to provide support to the direction of

the studies that focus on this field up until the National Green Building System is in place.

In previous Research/studies in this area, various aspects of the green building have been considered In Iran. For example in building regulations of the Ministry of Housing, the climate change issue has been addressed however the solutions do not address the use of ecosystem services such as green cover and green roof and are generally limited to only recommendation on the use of insulations and double-glazed windows. In the assessment system of Amirkabir University, there is a ranking system, but there are no climatic considerations and no reference to the benefits of ecosystem services. In the national physical plane, there are climatic classifications for heating, cooling and humidity, and on this basis, architectural proposals have been made to address each of the specific climatic condition, but nonetheless the use of ecosystem benefits has not been taken into account.

In this research, we have mainly introduced a new framework in the formulation of an urban green building quantitative model. The framework employs' ecosystem services benefits, with its criteria and weights are subject to the climatic conditions of the city. The weights become more precise by applying the results of related monetary valuations studies. In this way, it is hoped that this research will evolve in the direction expected by users to create a tool to identify methods to reduce construction-related carbon emissions and evaluate their effectiveness. Although this article is cited as an environmental model in urban construction, it can also cover other rural areas. The reason for referring to urban construction is due to its remarkable impact on the environment. In summary, this model can be used for countries with climate diversity. This of course requires appropriate localizations in relation to the model's monetary evaluations. However, this research is the first step in the establishment of a National Green Building System and has limited itself in only considering the air-related criteria. Due to the dryness of the region, the water criteria should also be added to the model in any future studies. Additionally, to monitor the system at the national level, it is necessary to use cloud technologies to deploy it in the spatial data infrastructure (SDI), such that it is interactively connected with the National Physical Plan and other urban development systems. We have already started this work and are hoping that in our future articles, the results can be presented. It should be possible to benefit from the National Physical Plan development to improve the compatibility of the green building system with the existential contour of the country. It is also recommended that future studies on monetary valuations should be developed to cover data model indications, as such that assessments can be made based on currency unit rather than UGBU.

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Appendix A. Monetary functions extracted from the green infrastructure valuation toolkit (West, 2010)

A.1

C32 : (C Indicative peak temperature) Tool 1.4 output - 1.4 Reduced peak summer surface temperatures ;
C32 =C30-C29
C30 : (C) Peak temperature after ;   =22.3(1/(C28+0.53))+2.2*C28+0.9*
C28 : ( ) Evaporative fraction after project ; =IF('Project Data '!E4=0,0,'Project Data '!E5/'Project Data '!E4)
'Project Data '!E4 : (ha) Project area – After; = User Defined
'Project Data '!E5 : (ha) Total area of greenspace - After ; = User Defined
C29 : (C) Peak temperature before ; =22.3(1/(C27+0.53))+2.2*C27+0.9*
C27 : ( ) Evaporative fraction before project (=green area before/total site area) ;   =IF('Project Data '!E4=0,0,'Project Data '!D5/'Project Data '!E4)
'Project Data '!E4 : (ha) Project area - After ; = User Defined
'Project Data '!D5 : (ha) Total area of greenspace - Before ; = User Defined

A.2

C63 : (£ NPV) Tool 1.7 output - 1.7 Carbon stored in woodland and forests ;
C63 =(C61'1 Climate'!G83)*
C61 : (tCO2/yr) Carbon sequestered ; =(C59+C58)'1 Climate'!D83*
C59 : (Ha) Tree cover increase from creation new wooded areas ;   =('Project Data '!E11)
'Project Data '!E11 : (ha) Area of new woodland created - Afte ; = User Defined
*C58 : (Ha) Tree cover increase from enhancement to existing wooded areas ;   =('Project Data '!D10*E58)*
'Project Data '!D10 : (ha) Tree cover - Before ; = User Defined
E58 : Tree cover increase from enhancement to existing wooded areas (%) assuming %5 ; = User Defined
'1 Climate'!D83 : (tC02/ha/yr) Broadleaves ; = 2.4
'1 Climate'!G83 : (NPV £/ha (50yrs@3.5%)) Broadleaves ; = 4315.49601003799

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